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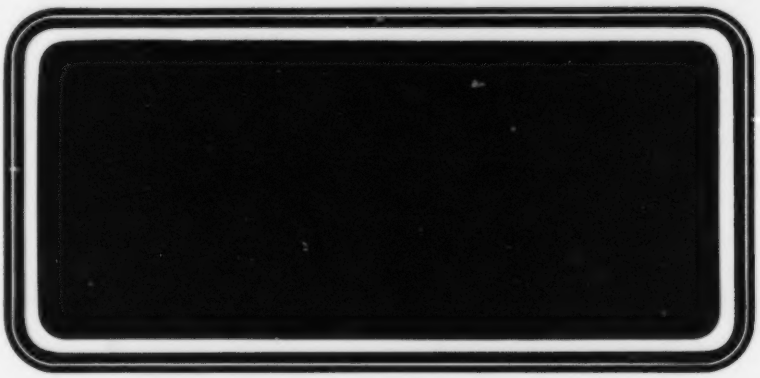

Canada Alberta

The Canada-Alberta Forest Resource Development Agreement is a subsidiary agreement of the Canada-Alberta Economic and Regional Development Agreement, which provides coordination and cooperation between the governments of Alberta and Canada in areas of Alberta's economic development.

The Canada-Alberta Forest Resource Development Agreement is funded equally by the governments of Canada and Alberta, from April 1, 1984, to March 31, 1989.

Its primary objectives are to ensure the long-term availability of timber supplies; to optimize timber uses; and to contribute to the growth and diversification of Alberta's economy.

The Agreement comprises three programs: Reforestation; Applied research, technology transfer and opportunity identification; and Public information, evaluation and administration. These programs are managed by a joint Directorate and are implemented by the Canadian Forestry Service and the Alberta Forest Service.

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L'Entente Canada-Alberta sur la mise en valeur des ressources forestières est financée à parts égales par les gouvernements du Canada et de l'Alberta, et a cours du 1er avril 1984 au 31 mars 1989.

Ses objectifs principaux sont assurer la disponibilité à long terme de réserves de bois; optimiser leur utilisation; et contribuer à la croissance et la diversification de l'économie de la province.

L'Entente comprend trois programmes: Reboisement; Recherche appliquée, transferts de connaissances techniques et relevé des occasions; et Information, évaluation et administration. Ces programmes sont gérés par un Bureau de direction conjoint, et mis en oeuvre par le Service canadien des forêts et le Service forestier de l'Alberta.

For more information, please call or write:

Pour de plus amples informations, veuillez vous adresser à:

Canadian Forestry Service
Northern Forestry Centre
5320 - 122 Street
Edmonton, Alberta
T6H 3S5
Telephone: (403) 435-7210
Attention: S. Price

OR/OU Alberta Department of
Forestry, Lands & Wildlife
9915 - 108 Street
Edmonton, Alberta
T5K 2C9
Telephone: (403) 427-3583
Attention: D. Fregren

PEST DISTRIBUTION AND IMPACT IN YOUNG LODGEPOLE PINE STANDS IN WEST-CENTRAL ALBERTA

P.A. Amirault and B. Pope[1]

1989

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[1]Forestry Canada, 5320-122nd St., Edmonton, Alberta T6H 3S5

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DISCLAIMER

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108th Street Building
#930, 9942 - 108th Street
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ABSTRACT

Young lodgepole pine (Pinus contorta Dougl. var. latifolia) stands in west-central Alberta were surveyed to detect the presence of pests and to determine the incidence of damage. In total 67 stands (from 5 to 23 years of age) were surveyed in three distinct areas within the Edson, Whitecourt, and Grande Prairie Forests. Western gall rust (Endocronartium harknessii (J.P. Moore) Y. Hiratsuka) was found to be the most widespread pest problem. Other diseases detected included Armillaria root rot (Armillaria obscura (Pers.) Herink), stalactiform blister rust (Cronartium coleosporioides Arth.), needle rust of hard pines (Coleosporium asterum (Diet.) Syd.), and comandra blister rust (Cronartium comandrae Pk.). Insect pests included pitch blister moths (Petrova spp. (Busck)), the Warren rootcollar weevil (Hylobius warreni Wood), and the lodgepole terminal weevil (Pissodes terminalis Hopping). Abiotic problems included hail damage, winter browning, and mechanical damage. Other problems included stem girdling by snowshoe hare (Lepus americanus Erxleben) and browsing. In general the rate of mortality increased as stands aged. Armillaria root rot and the Warren rootcollar weevil were the primary mortality causing agents. Comandra blister rust was restricted to one stand where almost one-third of the infected trees were dead.

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The survey methodology was developed cooperatively by representatives of Forestry Canada, the Provinces of Alberta, Saskatchewan, Manitoba, the Northwest Territories, and the University of Alberta through the Committee on Plantation Pest Surveys (see introduction). Paul Maruyama and Dr. H.R. Wong of Forestry Canada contributed by identifying disease and insect specimens, respectively.

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INTRODUCTION

Prior to 1987 surveys of pests in young stands had not been a regular part of the annual Forest Insect and Disease Survey conducted by Forestry Canada in the Northern Region (Alberta, Saskatchewan, Manitoba, and the Northwest Territories). In March of that year a Committee of Plantation Pest Surveys (COPPS) was formed with representatives of Forestry Canada, the Provinces within the region, the Northwest Territories, and the University of Alberta. Included in the objectives of the committee were to plan and initiate surveys to determine the incidence, distribution, and general abundance of known insect and disease pests, newly introduced pests and other damaging agents in young coniferous stands in the region.

In the spring of 1987 Forestry Canada and the provincial agencies implemented the surveys. In Alberta the survey area was the west-central part of the province. Stands of lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.), the dominant commercial tree species in the area, were surveyed. The surveys were conducted during the spring and summers of 1987 and 1988 using personnel and resources provided by the Canada-Alberta Forest Resource Development Agreement.

METHODS

Stands of lodgepole pine 5-30 years of age throughout the study area were potential candidates. Preliminary stand selections were made from lists of "suitably regenerated stands" provided by provincial agencies and private companies, or from forest inventory maps. Final selections depended on accessibility and on-site inspections (stands found to be poorly stocked or with dense competition were deleted). An attempt was made to sample the range of age classes available.

The survey occurred in three distinct areas. In summarizing the stand data these areas are referred to as the Edson, Grande Prairie, and Whitecourt Forests. Figure 1 is to be consulted for more specific information regarding the areas in which the stands occurred. These areas were selected because ongoing forest harvesting operations and subsequent regeneration efforts had provided a number of potential survey opportunities. The primary method of regeneration in the area was to prepare cutovers by scarification and then depend on natural regeneration from seed on the site, or to assist with broadcast applications of seed.

The stand surveys were begun by selecting a tiepoint on the stand boundary. From this tie point a cruise line which bisected the stand was established. At 90m intervals temporary sample plots which extended for 10m along the cruise line and which were 4m wide were established. In very small stands interplot distances were decreased in order to have a minimium of three plots.

Within the boundaries of the sample plots the heights of the first two lodgepole pine encountered were measured. All coniferous trees were examined for the presence of damaging pest problems. The examination procedure involved four stages. The root collar was checked for signs of root disease, insect, or animal damage. Stems and major branches were examined for evidence of animal damage, cankers, galls, dwarf mistletoe, etc. Foliage and buds were checked for defoliation, rusts, needle casts, browse, and abiotic damage. Terminal leaders were examined for weevil damage, defoliation, and breakage. Any pests encountered and the nature of the damage they caused were recorded on tally sheets (Appendix 1) using a series of damage and pest codes (Appendix 2). Potential pests for which no associated damage could be detected were not recorded. For example aphids were commonly found, without visible indications that the host was being harmed. The pest codes were designed for all pines in the Northern Region. It is for this reason that many of the pests listed do not occur on lodgepole pine.

All conifers on the sample plots were assigned one of four vigor codes:

01 - Vigorous - apparent normal health, little or no damage;
02 - Fairly vigorous - may have some chlorosis, defoliation, girdling, etc;
03 - Declining or dying - crown fading to yellow, severe defoliation for two or more years - may also have top dieback, roots or root collar girdled or heavy resinosis on root collar and roots; and
04 - Dead.

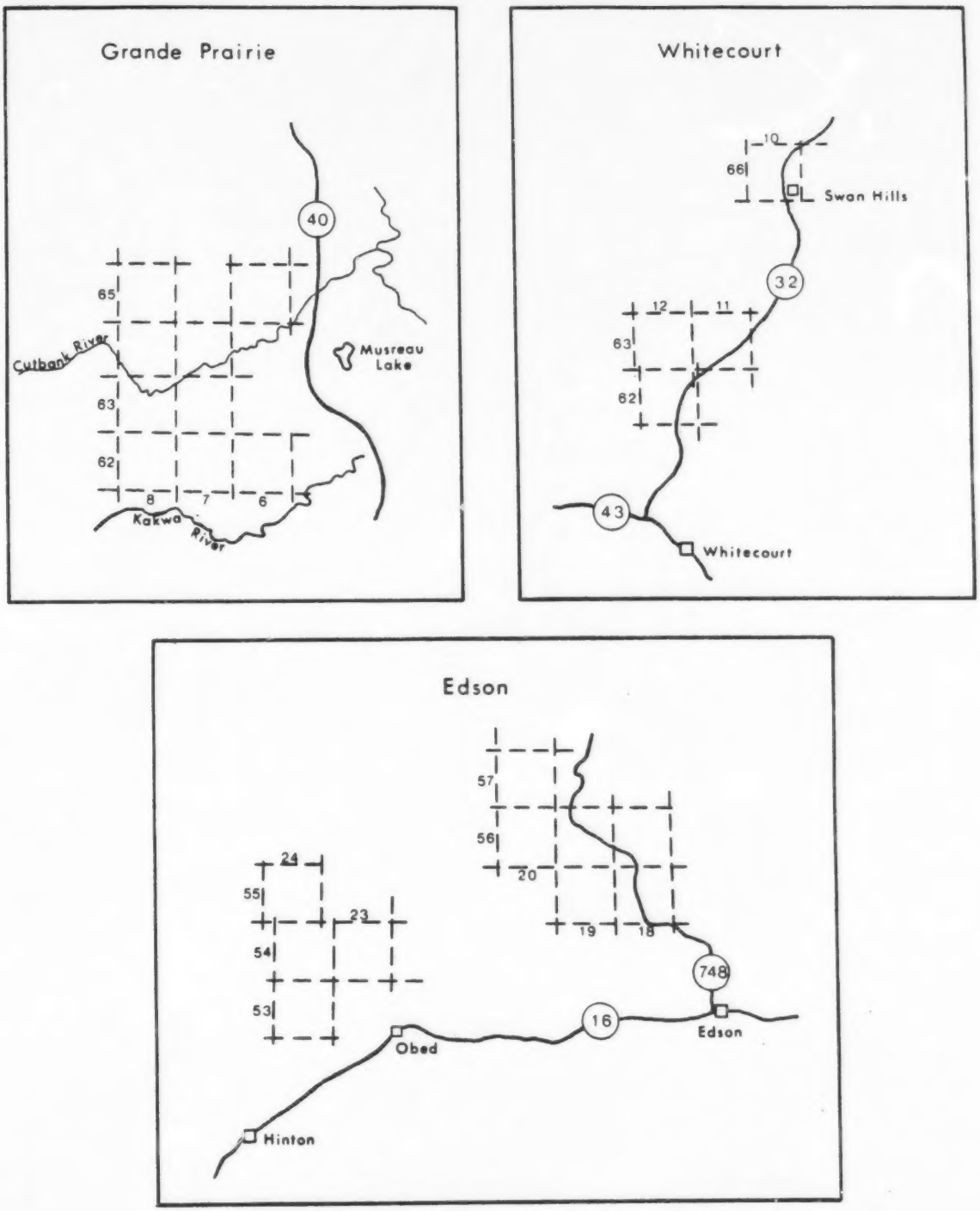

Figure 1. General areas involved in survey. Townships illustrated contain surveyed stands.

Instances of vegetative competition were noted for every tree examined. If competition existed it was categorized as either:

01 - Light - causing little or no interference to crop trees;
02 - Moderate - causing some interference to crop trees, but not significant enough to cause tree mortality and significant reductions in growth; and
03 - Severe - of sufficient intensity to cause tree mortality and significant growth suppression.

Further tree examinations were made throughout the stand area after the cruise line was completed and all plots established. This was accomplished by having the surveyors walk out of the stands on a course that roughly paralleled the initial cruise line. Their routes were offset from the line enough that they could examine areas of the stands not visible form the cruise line. Any problems encountered during this "walk through", which had not already been detected on the sample plots were noted. The stand boundaries and plot locations were sketched on the back of the tally sheets for future refreference. When necessary pests were collected for subsequent identification.

A total of 67 stands were surveyed. Table 1 summarizes the number of stands surveyed, the stand areas surveyed, the number of plots established, and the number of lodgepole pine examined in each Forest. The same information, plus average tree heights and stand ages are listed for each stand in Appendix 3. White spruce (Picea glauca (Moench) Voss), black spruce (Picea mariana (Mill) B.S.P.), balsam fir (Abies balsamea (l.) Mill.), and tamarack (Larix laricina (Du Roi) K. Koch) encountered on the plots were also examined. Limited information pertaining to these species is contained in various appendixes (4, 5, 7, 8, 10, and 11).

Table 1. Survey statistics by Forest.

Forest	# Stands Surveyed	Stand Area Surveyed (ha)	Number Plots Established	Number Pine Examined
Edson	19	556	57	4052
Whitecourt	22	645	107	6007
Grande Prairie	26	1288	142	6230

RESULTS

PEST DISTRIBUTION

A total of 14 different pest problems/damaging agents were encountered, with tree diseases being the most common. The numbers of stands in which each pest was located, are summarized by forest in Appendixes 5, 8, and 11. These Appendixes include pests detected during walk throughs in addition to on-plot tree examinations. The frequency of pest observations (percentage of trees containing individual pests in each forest, by age class) are summarized in Table 2. This includes information from plot trees only.

Western gall rust (caused by the rust fungus Endocronartium harknessii (J.P. Moore) Y. Hiratsuka) was detected in all stands in two Forests and in over 75% of the stands in the Whitecourt Forest (Appendixes 5, 8, and 11). Infestation rates for western gall rust exceeded those for other pests and surpassed 25% in the oldest age class in the Edson Forest (Table 2).

Armillaria root rot (predominantly caused by Armillaria obscura (Pers.) Herink) was common, except in the Grande Prairie Forest (Appendices 5, 8, and 11). The infection rate of 7.2% for the oldest stands in the Edson Forest, was in areas that had been pre-commercially thinned (Table 2).

Stalactiform blister rust (caused by the rust fungus (Cronartium coleosporioides Arth.)) was common in the Grande Prairie Forest and detected in the Whitecourt and Edson Forests (Appendixes 5, 8, 11). Infection rates were low in all areas (Table 2).

Needle rust of hard pines (the rust fungus Coleosporium asterum (Diet.) Syd.) was detected in half of the stands in the Grande Prairie Forest (Appendix 11). Over 5% of the trees examined throughout the forest were infected (Table 2).

Comandra blister rust (Cronartium comandrae Pk.) was detected in one stand in the Edson Forest. The number of infected trees accounted for 5% of the lodgepole pine in the 10-14 year age class (Table 2).

Pitch blister moths (Petrova albicapitana (Busck)) and P. metallica (Busck), Wong et al. 1985) were the most common insect pests detected (Appendixes 5, 8, and 11). They occurred at low levels in all age classes of every forest (Table 2).

The Warren root collar weevil (Hylobius warreni Wood) was found in only one stand in the Edson Forest (Appendix 5), but was more common elsewhere (Appendixes 8 and 11). Infection rates did not exceed 1% for any forest/stand age class.

Lodgepole terminal weevils (Pissodes terminalis Hopping) were scarce in the Whitecourt Forest (Appendix 8), but consistantly present elsewhere (Appendixes 5, 11).

Table 2. Percentages of lodgepole pine containing various pests (plot trees only).

Forest	Stand Age Class	Diseases					Insects			Other				
		WGR[1]	ARR	SBR	CBR	NER	PBM	RCW	LTW	BWS	HAIL	HAR	MECH	WBN
Edson	5-9	3.6	1.3	0.0	0.0	0.0	1.4	0.0	0.3	0.0	0.3	0.0	0.0	0.0
	10-14	13.8	1.4	0.0	5.0	0.0	3.1	0.1	1.6	2.3	3.7	0.6	0.1	0.0
	15-19	23.9	1.9	0.0	0.0	0.0	1.4	0.0	1.5	0.3	3.2	0.3	0.5	0.0
	20-24[2]	28.4	7.2	2.0	0.0	0.0	2.0	0.0	0.7	0.0	0.0	6.0	0.0	0.0
Whitecourt	5-9	0.7	0.8	+[3]	0.0	0.0	0.5	0.6	0.0	+	0.0	0.0	0.0	0.0
	10-14	2.1	0.6	0.0	0.0	0.0	1.1	0.4	+	0.3	0.0	0.7	+	0.0
Grande Prairie	5-9	2.2	0.0	0.2	0.0	6.1	0.2	0.4	0.1	0.1	0.3	0.0	+	0.8
	10-14	16.0	0.0	0.5	0.0	5.7	0.5	0.3	0.0	1.5	1.1	0.0	+	2.2

[1] Legend: WGR - western gall rust
ARR - armillaria root rot
SBR - stalactiform blister rust
CBR - comandra blister rust
NER - needle rust
PBM - pitch blister moths
RCW - root collar weevil
LTW - lodgepole terminal weevil
BWS - browsing
HAIL - hail damage
HAR - hare damage
MECH - mechanical damage
WBN - winter browning

[2] All stands in this age class had been thinned.

[3] Less than 0.1 %.

One specimen of a Dioryctria sp. was detected in the Edson Forest.

Other damaging agents included browsing, hail damage, winter browning, mechanical damage, and snowshoe hare (Lepus americanus Erxleben) damage. These occurred in variable amounts throughout the study areas (Appendixes 5, 8, 11 and Table 2). Concentrations of hail and hare damage were evident in the Edson Forest and winter browning in the Grande Prairie Forest (Table 2).

PEST IMPACT

The relative health of stands in various areas and age classes was compiled (Figure 2). As the stands aged the frequency of pest problems and mortality tended to increase. It should be noted that damaged trees (Figure 2) include all those for which a damage code was used. The amount of actual damage to the trees involved varies greatly depending on the pest involved. Mortality was generally low, in no Forest/age class did it excede 10%. Complete stand listings of condition classes can be found in Appendixes 4, 7, and 10.

Mortality factors for the various areas were summarized (Figure 3). Armillaria root rot was a significant mortality factor in all but the Grande Prairie Forest. The Warren rootcollar weevil caused mortality in the Whitecourt and Grande Prairie Forests. Comandra blister rust was a significant mortality factor in the Edson Forest. More complete listings of mortality agents (by forest) can be found in Appendixes 6, 9, and 12.

Armillaria root rot and the Warren rootcollar weevil frequently occur together on dead and dying lodgepole pine in west-central Alberta. Table 3 summarizes the relative abundance of these pests and their simultaneous occurance in each forest. The elevated relative frequency of armillaria in the Edson Forest, and the Warren rootcollar weevil in the Grande Prairie Forest was evident. The data from the Whitecourt Forest suggested an intermediate condition.

Table 3. Occurrence of tree death caused by armillaria root rot, the Warren rootcollar weevil, and both.

Forest	Number of Dead Trees With		
	Armillaria	Root Collar Weevil	Armillaria/Weevil
Edson	61	3	2
Whitecourt	25	21	7
Grande Prairie	0	12	0

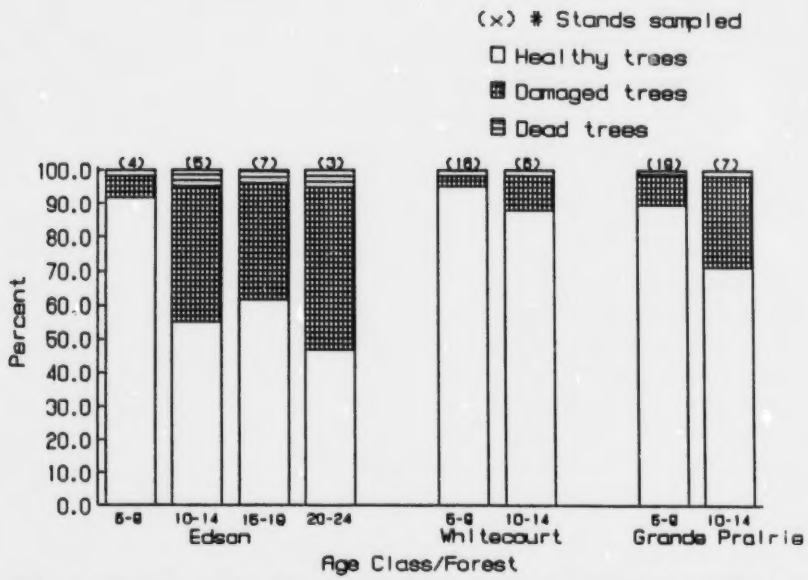

Figure 2. Percentage of lodgepole pine in various condition classes, summarized by age class and forest.

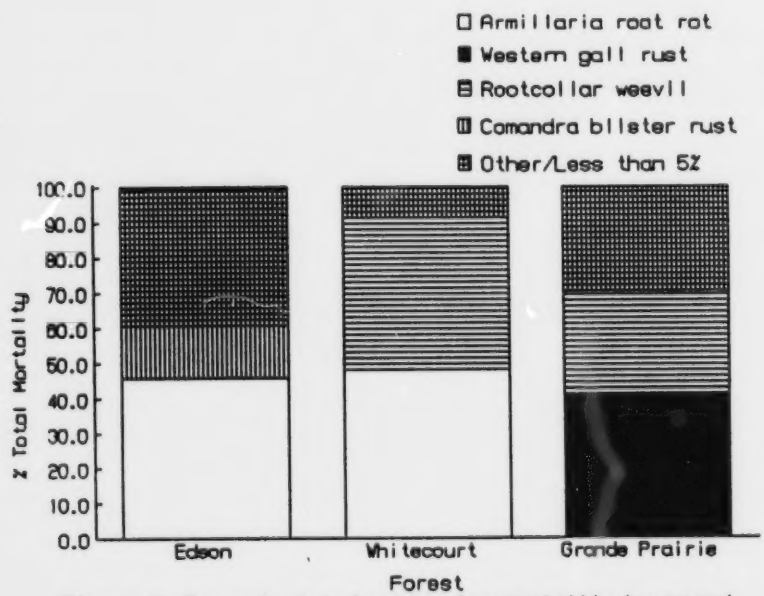

Figure 3. Percentage lodgepole pine mortality by causal agent.

Pine stem rusts were common in all Forests. Table 4 relates the presence of pine stem rusts to the vigor of infected trees in each area. Only trees without other pest problems were included and rusts that infected less than five trees per Forest (i.e. stalactiform blister rust in the Edson and Grande Prairie Forests) were not included.

The majority (91.5%) of trees infected with western gall rust were healthy (Table 4). Mortality caused by this pathogen was largely confined to the Grande Prairie Forest, where the number of infections/tree was particularly high in some stands.

Comandra blister rust had killed 29.8% of the trees it had infected (Table 4). Stalactiform blister rust was more wide spread, but less likely to cause tree mortality. This concurs with the work of Hiratsuka and Powell (1988) who described comandra blister rust as the most aggressive stem-girdling rust contributing to tree mortality (in Alberta and the Northwest Territories).

Needle cast did not appear to be impacting on host trees. It occurred alone on 125 trees in 5-9 year-old stands in the Grande Prairie Forest. All but one tree was rated vigor class one, with the exception being a two. All 86 infected trees in stands 10-14 years were rated vigor class one.

Pitch blister moths caused localized damage to stems and branches that sometimes led to leader and branch breakage. Ives and Wong (1988) noted that P. albicapitana seldom girdles the stem completely. P. metallica nodules are often found at the point where branches have broken after being weakened by larval tunnelling.

It did not appear that colonization of trees by the lodgepole terminal weevil led to serious deformities, except in very isolated instances. The usual course of events was for a lateral shoot to establish dominance leaving a slight crook. It has been suggested that the lodgepole terminal weevil has a preference for the tallest, most vigorous trees (Bella 1985).

Browsing damage was predominantly foliage clipping that appeared to be caused by elk (Cervus canadensis nelsoni Bailey), deer (Odocoileus spp.) or moose (Alces alces Gray). Winter browning and mechanical damage caused localized damage to individual trees. Hail damage was severe in localized areas in the Edson and Grande Prairie Forests. Damage manifested itself as stem lesions and broken branches. There was no evidence of hail-caused defoliation as described by Dobbs and McMinn (1973).

Snowshoe hares were responsible for incomplete (normally) girdling of the basal portions of trees. Damage appeared to be concentrated in areas where ground vegetation provided cover for the animals. Radvanyi (1987) reported they prefer habitats that provide dense vegetative cover 1-2m above the ground. In the case of young stands in clear-cut areas damage would be expected to be concentrated near the edges because high densities of snowshoe hare are generally not found further than 200-400m from conifer cover (Keith 1974; Keith et al. 1984). Older coniferous stands are used exten-

Table 4. Vigor classes of trees containing stem infections of various pine stem rusts.

Forest Type of stem rust	Stand Age Class	Number of infected trees in vigor class 1*	2	3	4
EDSON					
Western Gall Rust	5-9	29	0	0	0
	10-14	60	0	0	1
	15-19	209	2	3	3
	20-24	30	3	1	0
Comandra Blister Rust	10-14	33	0	0	14
WHITECOURT					
Western Gall Rust	5-9	12	2	1	0
	10-14	16	0	1	1
GRANDE PRAIRIE					
Western Gall Rust	5-9	68	1	12	5
	10-14	173	1	7	12
Stalactiform Blister Rust	5-9	8	0	1	0
	10-14	4	0	0	0

* Vigor Class 1. vigorous
2. fairly vigorous
3. declining
4. dead

sively in winter after the trees have sufficient height to provide 60% foliage coverage at 1-3m above the ground (Radvanyi 1987). During periods of high populations hares occupy less favorable habitats and participate in mass movements in search of food (Radvanyi 1987).

DISCUSSION

The primary purpose of the survey was to assess pest distribution and abundance. The amount of pest impact information which could be gleaned was limited by the low sampling intensities employed. It is for this reason that impact assessment was of a very general nature.

There appear to be noticable differences in pest abundance between geographical areas. This was illustrated by the comparison of armillaria root rot and Warren rootcollar weevil occurrence in various forests; the confinement of needle rust of hard pines to one forest, and comandra blister rust to one stand.

Armillaria root rot, the Warren rootcollar weevil, and comandra blister rust were found to be primary causes of mortality. Western gall rust was a mortality causing agent where infections were heavy. Any of these pests could potentially affect stand development when present in heavy concentrations. Stalactiform blister rust showed less potential as a mortality causing agent. The influences of hail damage, winter browning, and hare damage did not appear as major factors during the survey. Damage caused by these agents can be quite severe given more intense meteorological conditions, or in the case of hares during population cycle peaks (Hiratsuka 1988). Needle rust of hard pines, the pitch blister moths, and lodgepole terminal weevil affected trees in a sub-lethal manner.

It is intended that surveys of this manner will continue in Alberta. Among the future goals are to expand the survey to other areas, survey undersampled age classes in the current areas, and to expand sampling to other tree species. There also is a possibility that surveys specifically designed to measure the impact of various pests will be designed and implemented.

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APPENDIX 1

TALLY SHEET USED DURING SURVEY

PEST SURVEY OF YOUNG STANDS

UTM_____ Province_____ Region/Forest_____ FMU_____ Twp./Rg./Mer._____

Plantation No._____ Plot No._____ Date Prev. Ass._____ Logging Date_____ Site Prep_____

Planted/Natural_____ Stock Type _____ Date Stand Orig._____ Average Age_____

Stand Area_____ General Topography_____ Crew_____ Date_____

Tree #	Sp.	Ht. (m)	DBH (cm)	Damage Code	Causal Agent	Vigour Code	Competition Code	Remarks

Appendix 2. Damage and pest codes used during survey.

Damage Codes

01 - Chlorosis - especially on current or one-year-old needles in upper crown.
02 - Defoliation - restricted to current years shoots; light, moderate, severe.
03 - Defoliation - one year old and older needles; light, moderate, severe.
04 - Bud, shoot, and branch dieback - especially in upper crown.
05 - Leader dieback - current year or previous years.
06 - Stem cankers or galls - pine stem rusts.
07 - Partial or complete girdling - stem or root collar.
08 - Resinosis - especially lower stem, root-collar, roots.
09 - Stem deformity.
10 - Cone and/or seeds.
11 - Other.

Pest Codes - Pine Hosts

Insect and Disease Damage

I Roots and Root Collar Damage

Insects	Code
Root Collar Weevils	001 - Hylobius radicis (pine rootcollar weevil)
	002 - Hylobius warreni (Warren root-collar weevil)
White Grubs	003 - Phyllophaga spp. (June beetles)
Other	004 - Explain
Diseases	
Root Rot	005 - Armillaria obscura (Armillaria root rot)
Root and Root Collar Disease	006 - Verticicladiella sp.
Other	007 - Explain
Non-infectious Damage	
Root Deformities	008 - "J" shaped
	009 - Club shaped
	010 - Paperpot intact
	011 - Multiple trees
Improper Planting	012 - Shallow
	013 - Deep planting

Appendix 2. (continued)

II Stem or Branch Damage

Insects

Terminal Weevils	014 - Pissodes strobi (white pine weevil) 015 - Pissodes terminalis (lodgepole terminal weevil)
Shoot Borer	016 - Eucosma gloriola (eastern pine shoot borer)
Pitch Blister Moths	017 - Petrova spp.
Scale Insect	018 - Toumeyella numismaticum (pine tortoise scale)
Aphids	019 - Cinara spp. (pine bark aphids)
Spittlebugs	020 - Aphrophora parallela
Bark Beetles	021 - Ips spp.
Pitch Midge	022 - Cecidomyia reeksi (jack pine resin midge)
Coneworms	023 - Dioryctria abietivorella (fir coneworm) 024 - Dioryctria disclusa (rusty pine cone moth)
Other	025 - Explain

Diseases

Dwarf Mistletoe	026 - Arceuthobium americanum (lodgepole pine dwarf mistletoe)
Gall Rust	027 - Endocronartium harknessii (western gall rust)
Rust Cankers	028 - Cronartium comptoniae (sweet fern blister rust) 029 - Cronartium comandra (comandra blister rust) 030 - Gremmeniella abietina (scleroderris canker)
Other	031 - Explain

Non-infectious Damage

Animal Browsing Damage	032 - Deer 033 - Mice 034 - Squirrels 035 - Moose 036 - Hare

Appendix 2. (continued)

Bird Damage	037 - Sapsucker
Mechanical Damage	038 -
Other	039 - Explain

III Foliage Damage

Insects

Budworm	040 - *Choristoneura pinus pinus* (jack pine budworm)
Sawflies	041 - *Diprion similis* (introduced pine sawfly) 042 - *Neodiprion virginianus* complex (redheaded pine sawfly) 043 - *Neodiprion sertifer* (European pine sawfly) 044 - *Neodiprion swaini* (Swaine jack pine sawfly) 045 - *Neodiprion pratti banksianae* (jack pine sawfly)
Webworm	046 - *Tetralopha robustella* (pine webworm)
Scale	047 - *Pherocaspis pinifoliae*
Other	048 - Explain

Diseases

Needlecasts	049 - *Lophodermium pinastri* (lophodermium needlecast) 050 - *Davisomycella ampla*
Needlerust	051 - *Coleosporium asterum*
Other	052 - Explain

Non-infectious

	053 - Frost 054 - Winter browning 055 - Summer drought
Other	056 - Explain
-	057 - *Zieraphera*

Appendix 3. Individual stand data.

Forest Stand #	Avg. Ht.(m)	Avg. Age	Site History	Area (ha)	# Trees Examined
Edson				[1]	[2]
87-2	1.8	12	Natural	6(12)	223(Pl) 273(Sb) 337(Fb)
87-3	2.5	17	Natural	13(16)	732(Pl) 82(Sw) 56(Fb)
87-4	2.7	16	Natural	7(13)	252(Pl) 33(Sw) 27(Fb)
87-5	2.8	19	Natural	5(7)	28(Pl) 113(Sw) 219(Fb)
87-6	3.4	14	Natural	16(25)	752(Pl) 29(Sw)
87-7	2.5	9	Natural	6(9)	151(Pl) 25(Sw) 1(Fb)
87-8	1.2	8	Natural	6(10)	145(Pl) 24(Sw) 91(Fb)
Whitecourt					
87-10	1.1	5	Planted	3(6)	50(Pl)
87-13	1.6	10	Seeded	1(3)	173(Pl) 4(Sw)
87-14	1.2	10	Natural	3(5)	422(Pl) 2(Sw)
87-15	1.2	10	Natural	4(6)	647(Pl) 13(Sw)
88-1	0.8	10	Natural	12(4)	399(Pl) 35(Sw)

Appendix 3. (continued)

Forest Stand #	Avg. Ht.(m)	Avg. Age	Site History	Area (ha)	# Trees Examined
Whitecourt					
88-2	0.9	12	Natural	12(4)	59(Pl) 104(Sw) 49(Fb)
88-3	1.1	10	Natural	55(8)	597(Pl) 47(Sw) 11(Fb)
Grande Prairie					
88-4	0.6	9	Natural	11(4)	133(Pl) 78(Sw) 32(Fb)
88-5	0.7	9	Natural	35(4)	722(Pl)
88-6	1.0	8	Natural	15(3)	270(Pl) 3(Sw)
88-7	0.8	8	Seeded	53(5)	348(Pl) 1(Sw)
88-8	0.4	5	Planted	21(3)	10(Pl) 1(Sw)
88-9	0.7	12	Natural	21(6)	146(Pl) 18(Sb)
88-10	0.4	9	Seeded	23(5)	468(Pl) 43(Sw)
88-11	0.9	10	Natural	154(6)	641(Pl) 2(Sw)
88-12	0.8	8	Natural	66(7)	252(Pl) 2(Sw)
88-13	0.5	8	Planted	22(7)	227(Pl) 53(Sw)
88-14	0.7	8	Natural	56(5)	335(Pl) 3(Sw)
88-15	0.9	8	Natural	65(7)	334(Pl) 5(Sw)

Appendix 3. (continued)

Forest Stand #	Avg. Ht.(m)	Avg. Age	Site History	Area (ha)	# Trees Examined
Grande Prairie					
88-16	1.3	11	Natural	57(4)	68(Pl) 57(Sb)
88-17	0.7	11	Natural	33(5)	38(Pl) 24(Sb)
88-18	2.8	13	Planted	75(6)	180(Pl) 120(Sw) 21(Fb)
88-19	2.0	11	Natural	61(5)	326(Pl) 41(Sw)
88-20	0.9	7	Planted	106(8)	191(Pl) 142(Sw) 8(Fb)
88-21	1.0	8	Natural	41(4)	60(Pl) 8(Sw)
88-22	0.7	7	Natural	25(5)	86(Pl) 9(Sw)
88-23	2.0	11	Natural	58(7)	320(Pl)
88-24	0.9	8	Natural	35(4)	96(Pl) 56(Sb)
88-26	0.7	8	Seeded	46(5)	141(Pl) 32(Sb)
88-27	0.8	8	Seeded	59(8)	184(Pl) 105(Sw) 1(Fb)
88-28	1.0	8	Natural	53(7)	380(Pl) 51(Sw)
88-29	0.9	8	Natural	38(4)	144(Pl) 8(Sw)
88-30	0.6	8	Natural	59(8)	130(Pl) 29(Sw)

Appendix 3. (continued)

Forest Stand #	Avg. Ht.(m)	Avg. Age	Site History	Area (ha)	# Trees Examined
Whitecourt					
88-31	0.6	6	Seeded	21(4)	179(Pl) 4(Sw) 5(Fb)
88-32	0.7	6	Seeded	68(6)	242(Pl) 12(Sw) 1(Fb)
88-33	0.8	6	Seeded	99(8)	165(Pl) 3(Sw) 3(Fb)
88-34	0.9	8	Seeded	68(6)	377(Pl) 1(Sw)
88-35	0.8	8	Seeded	24(6)	157(Pl) 5(Sw) 1(Fb)
88-36	0.6	8	Seeded	20(4)	133(Pl)
88-37	1.0	8	Seeded	20(3)	221(Pl) 1(Sw)
88-38	1.0	8	Seeded	25(3)	145(Pl) 1(Sw)
88-39	0.9	8	Seeded	64(7)	496(Pl) 1(Sw)
88-40	1.0	8	Seeded	25(5)	737(Pl)
88-41	0.7	6	Natural	35(5)	75(Pl) 1(Sw)
88-42	1.4	9	Seeded	25(3)	70(Pl)
88-43	1.5	9	Seeded	48(5)	256(Pl) 1(Sw)
88-44	1.3	9	Seeded	7(3)	224(Pl) 3(Sw)
88-45	1.7	9	Seeded	6(3)	183(Pl)

Appendix 3. (continued)

Forest Stand #	Avg. Ht.(m)	Avg. Age	Site History	Area (ha)	# Trees Examined
Edson					
88-46	3.0	17	Natural Spaced	63(5)	86(Pl) 11(Sw) 7(Fb)
88-47	2.9	11	Natural	23(3)	92(Pl) 15(Sw)
88-48	2.0	14	Natural Spaced	80(3)	37(Pl)
88-49	1.8	14	Natural	48(5)	108(Pl) 1(Sw)
88-50	3.0	17	Natural	29(6)	95(Pl) 11(Sw) 7(Fb)
88-51	1.1	9	Natural	28(5)	383(Pl) 9(Sw)
88-52	2.9	23	Natural Spaced	27(5)	45(Pl) 2(Sw)
88-53	3.0	23	Natural Spaced	17(4)	35(Pl) 3(Sw) 1(Fb)
88-54	1.0	9	Natural	14(6)	397(Pl)
88-55	3.6	22	Natural Spaced	16(4)	71(Pl) 2(Sw)
88-56	3.3	17	Natural Spaced	116(6)	214(Pl) 10(Sw) 23(Fb)
88-57	2.5	17	Natural	24(5)	125(Pl) 50(Sw) 3(Fb)

1. number of plots established ()
2. Pl - lodgepole pine
   Sw - white spruce
   Sb - black spruce
   Fb - balsam fir

Appendix 4. Percentage of trees in various condition classes, Edson Forest.

Stand #	Species	Healthy	Damaged	Dead
	[1]			
87-2	Pl	65.0	34.5	0.5
	Sw	98.2	1.8	
	Fb	95.5	4.5	
87-3	Pl	82.1	16.5	1.4
	Sw	100.0		
	Fb	89.3	10.7	
87-4	Pl	69.4	30.2	0.4
	Sw	100.0		
	Fb	100.0		
87-5	Pl	35.7	50.0	14.3
	Sw	99.1	0.9	
	Fb	92.7	7.3	
87-6	Pl	65.3	27.9	6.8
	Sw	93.1	6.9	
87-7	Pl	78.1	17.2	4.7
	Sw	100.0		
	Fb	100.0		
87-8	Pl	82.8	12.4	4.8
	Sw	91.7	8.3	
	Fb	84.6	1.4	
88-46	Pl	28.7	64.4	6.9
	Sw	90.9	9.1	
	Fb	28.6	71.4	
88-47	Pl	47.1	49.4	3.5
	Sw	93.3	6.7	
88-48	Pl	56.7	43.3	
88-49	Pl	75.9	24.1	
	Sw	100.0		

Appendix 4. (continued)

Stand #	Species	Healthy	Damaged	Dead
88-50	Pl	61.0	36.8	2.2
	Sw	100.0		
	Fb	100.0		
88-51	Pl	96.3	2.2	1.5
	Sw	100.0		
88-52	Pl	62.2	24.4	13.4
	Sw	100.0		
88-53	Pl	40.0	48.6	11.4
	Sw	100.0		
	Fb	100.0		
88-54	Pl	95.9	3.0	1.1
88-55	Pl	59.1	39.7	1.2
	Sw	100.0		
88-56	Pl	45.8	51.9	2.3
	Sw	100.0		
	Fb	100.0		
88-57	Pl	52.0	44.8	3.2
	Sw	100.0		
	Fb	100.0		

1. Species Pl - lodgepole pine
Sw - white spruce
Fb - balsam fir

Appendix 5. Frequency of problems encountered on various tree species, Edson Forest. Total of 19 stands.

	Number of Stands		
	Pine	Spruce	Fir
Armillaria Root Rot	15		
Browsing	5	1	2
Comandra Blister Rust	1		
Dioryctria sp.	1		
Frost Damage		2	4
Hail Damage	5		
Girdling(hare)	5		
Mechanical Damage	5		2
Pitch Blister Moths	12		
Rootcollar Weevil	1		
Stalactiform Blister Rust	2		
Terminal Weevil	12		
Western Gall Rust	19		1
Winter Browning	1		

Appendix 6. Pine mortality by causal agent, Edson Forest.

Stand #	Dead Trees (#)	Number of Trees Killed by						
		WGR	CBR	SBR	RCW	ARR	Comb	Other
87-1	0							
87-2	1							1
87-3	10				3	5		2
87-4	1					1		
87-5	4					4		
87-6	51	2	20			6		23
87-7	7					1		6
87-8	7					4		3
88-46	6					6		
88-47	4					4		
88-48	0							
88-49	4					4		
88-50	2					2		
88-51	6					5	1	
88-52	6					6		
88-53	4					4		
88-54	4					3		1
88-55	5			3			1	1

Appendix 6. (continued)

Stand #	Dead Trees (#)	Number of Trees Killed by						
		WGR	CBR	SBR	RCW	ARR	Comb	Other
88-56	5	2				3		
88-57	4	1				3		

Legend: WGR - western gall rust
CBR - comandra blister rust
SBR - stalactiform blister rust
RCW - rootcollar weevil
ARR - armillaria root rot
Comb - combination of ARR and RCW
Other - includes unidentified and less common causes of mortality

Appendix 7. Percentage of trees in various condition classes, Whitecourt Forest.

Stand #	Species	Healthy	Damaged	Dead
	[1]			
88-1	Pl	95.5	4.3	0.2
	Sw	100.0		
88-2	Pl	72.8	27.2	
	Sw	100.0		
	Fb	100.0		
88-3	Pl	93.7	4.3	2.0
	Sw	95.9		
88-31	Pl	96.6	4.4	
	Sw	75.0	25.0	
	Fb	60.0	40.0	
88-32	Pl	97.1	2.5	0.4
	Sw	100.0		
	Fb	100.0		
88-33	Pl	95.7	2.4	1.9
	Sw	100.0		
	Fb	100.0		
88-34	Pl	99.0	0.7	0.3
	Sw	100.0		
88-35	Pl	99.4	0.6	
	Sw	100.0		
	Bf	100.0		
88-36	Pl	95.5	2.3	2.3
88-37	Pl	96.0	3.6	0.4
	Sw	100.0		
88-38	Pl	91.0	0.7	8.3
	Sw	100.0		
88-39	Pl	95.7	3.4	0.9
	Sw	100.0		
88-40	Pl	98.5	0.7	0.8

Appendix 7. (continued)

Stand #	Species	Healthy	Damaged	Dead
88-41	Pl	98.6	1.4	
	Sw	100.0		
88-42	Pl	50.7	46.5	2.8
88-43	Pl	94.5	2.7	2.8
88-44	Pl	96.4	3.6	
	Sw	100.0		
88-45	Pl	96.7	3.3	
	Sw	100.0		
87-10	Pl	64.0	36.0	
87-13	Pl	91.9	8.9	
	Sw	100.0		
87-14	Pl	95.5	3.6	0.9
	Sw	100.0		
87-15	Pl	97.4	1.5	1.1
	Sw	100.0		

1. Species Pl - lodgepole pine
Sw - white spruce
Fb - balsam fir

Appendix 8. Frequency of problems encountered on various tree species, Whitecourt Forest. Total of 22 stands.

	Number of Stands		
	Pine	Spruce	Fir
Armillaria Root Rot	13		
Browsing	7		
Frost Damage		1	
Mechanical Damage	2		
Pitch Blister Moths	13		
Rootcollar Weevil	11		
Stalactiform Blister Rust	1		
Terminal Weevil	2		
Western Gall Rust	17		
Winter Browning	11	1	1

Appendix 9. Pine mortality by causal agent, Whitecourt Forest.

Stand #	Dead Trees (#)	Number of Trees Killed				
		WGR	RCW	ARR	Comb	Other
88-1	1			1		
88-2	0					
88-3	8			8		
88-31	0					
88-32	0					
88-33	1		1			
88-34	2		2			
88-35	0					
88-36	3		3			
88-37	1		1			
88-38	12		6	2	4	
88-39	3		1	1		1
88-40	6	1		4	1	
88-41	0					
88-42	2					1
88-43	7			7		
88-44	0					
88-45	0					

Appendix 9. (continued)

Stand #	Dead Trees (#)	Number of Trees Killed				
		WGR	RCW	ARR	Comb	Other
87-10	0					
87-13	0					
87-14	4			1	2	1
87-15	7		7			

Legend: WGR - western gall rust
RCW - rootcollar weevil
ARR - armillaria root rot
Comb - combination of ARR and RCW
Other - includes unidentified and less common causes of mortality

Appendix 10. Percentage of trees in various condition classes, Grande Prairie Forest.

Stand #	Species	Healthy	Damaged	Dead
	[1]			
88-4	Pl	95.5	3.7	0.8
	Sw	97.4	1.3	1.3
	Fb	96.9	3.1	
88-5	Pl	74.3	25.2	0.5
88-6	Pl	97.4	2.6	
	Sw	100.0		
88-7	Pl	97.7	2.0	0.3
88-8	Pl	100.0		
	Sw	100.0		
88-9	Pl	69.2	30.1	0.7
	Sw	100.0		
88-10	Pl	94.7	5.1	0.2
	Sw	100.0		
88-11	Pl	87.7	12.2	0.1
	Sw	100.0		
88- 12	Pl	87.6	11.9	0.5
	Sw	100.0		
88-13	Pl	85.0	14.5	0.5
	Sw	100.0		
88-14	Pl	97.3	2.1	0.6
	Sw	100.0		
88-15	Pl	70.5	29.0	0.5
	Sw	100.0		
88-16	Pl	81.8	15.2	2.3
	Sw	100.0		
88-17	Pl	81.5	13.1	5.4
	Sw	96.0	4.0	
	Fb	100.0		

Appendix 10. (continued)

Stand #	Species	Healthy	Damaged	Dead
88-18	Pl	46.7	52.2	1.1
	Sw	100.0		
	Fb	100.0		
88-19	Pl	76.5	22.8	0.7
	Sw	100.0		
88-20	Pl	90.1	8.9	1.0
	Sw	100.0		
	Fb	100.0		
	Le	100.0		
88-21	Pl	96.5	1.5	2.0
	Sw	100.0		
88-22	Pl	87.2	11.6	1.2
	Sw	100.0		
88-23	Pl	55.3	42.8	1.9
88-24	Pl	89.9	9.1	1.0
	Sw	98.2	1.8	
88-26	Pl	91.4	7.9	0.7
	Sw	94.1	5.9	
88-27	Pl	97.3	2.7	
	Sw	98.1	1.9	
88-28	Pl	96.0	4.0	
	Sw	98.0	2.0	
88-29	Pl	93.1	6.2	0.7
	Sw	100.0		
88-30	Pl	99.2	0.8	
	Sw	100.0		

1. Species Pl - lodgepole pine
Sw - white spruce
Fb - balsam fir
Le - tamarack

Appendix 11. Frequency of problems encountered on various tree species, Grande Prairie Forest. Total of 26 stands.

	Number of Stands		
	Pine	Spruce	Fir
Armillaria Root Rot	3		
Browsing	10	1	1
Hail Damage	3	1	
Mechanical Damage	3		
Needle Rust	13		
Pitch Blister Moths	11		
Rootcollar Weevil	13		
Stalactiform Blister Rust	11		
Terminal Weevil	11		
Western Gall Rust	26		
Winter Browning	10	2	

Appendix 12. Pine mortality by causal agent, Grande Prairie Forest.

Stand #	Dead Trees (#)	Number of Trees Killed		
		WGR	RCW	Other
88-4	1			1
88-5	4	3		1
88-6	0			
88-7	0			
88-8	0			
88-9	1	1		
88-10	1		1	
88-11	1	1		
88-12	1	1		
88-13	1		1	
88-14	2		1	1
88-15	2		1	1
88-16	2		2	
88-17	2		1	1
88-18	2	2		
88-19	4	4		
88-20	2		1	1
88-21	5	1	4	
88-22	1			1
88-23	6	5		1

Appendix 12. (continued)

Stand #	Dead Trees (#)	Number of Trees Killed		
		WGR	RCW	Other
88-24	0			
88-25	0			
88-26	1			1
88-27	0			
88-28	0			
88-29	1			1
88-30	0			

Legend: WGR - western gall rust
RCW - rootcollar weevil
Other - includes unidentified and less common causes of mortality